Reports and Letters

Inherent Inconsistencies in Fluorescence and Scintillation Spectra

Various qualitative studies of emission spectra of liquid solution scintillators have been reported (*1*). Quantitative spectra have now been obtained from a number of solutions (*2*). The solutions, which were contained in cylindrical cells with lateral windows, were excited both with a 100-mc Cs^{137} source and with a mercury lamp directed to the top surface or to the front face of the cells. Densitometer tracings of the spectrograms, corrected for dispersion, for instrument and emulsion sensitivity, and for relative photon energy, provide spectra, the relative areas of which are proportional to the relative light-producing efficiencies of the solutions.

When another conversion factor for the spectral response of a photomultiplier cathode is applied, curves of relative number of photoelectrons plotted against wavelength are obtained. The relative areas of this type of curve obtained from scintillation spectra have been found to be in the same ratio as the relative pulse heights (*3*) of the scintillator solutions.

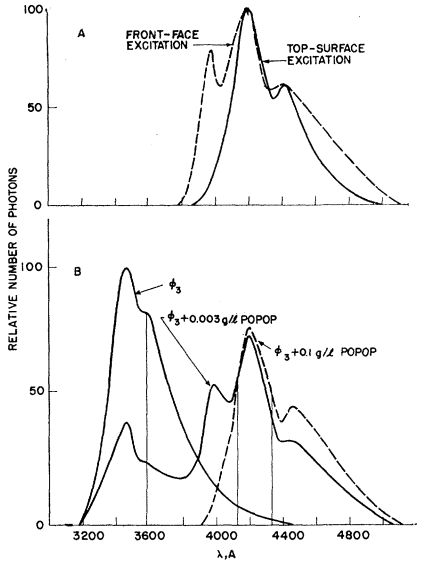

Fig. 1. (*A*) Fluorescence spectra of 4 g/lit ϕ_3 with 0.1 g/lit of POPOP in toluene; (*B*) scintillation spectra.

Illustration is provided in Fig. 1 by spectra that were obtained with the most efficient liquid-solution scintillator currently in use (*3*). Figure 1*A* shows the curves obtained by the two methods of ultraviolet excitation from a toluene solution of 4 g/lit of *p*-terphenyl (ϕ_3) with 0.1 g/lit of 1,4-di-[2-(5-phenyloxazoly)]-benzene (POPOP) (*4*) as secondary solute (wavelength shifter). The ordinate scale is in arbitrary units, and the curves are not comparable in this dimension. The shorter-wavelength peak at 4000 A is present with front-face excitation and not with top-surface excitation.

The front-face spectra remain practically the same in both intensity and structure as the POPOP concentration is varied from 0.1 to 0.001 g/lit; under overexposure conditions, the terphenyl spectrum is also present. The top-surface spectra in this range of concentrations do not show the terphenyl contribution even under overexposure conditions. The 4000-A peak is present at 0.01 g/lit and less. However, the over-all intensities of the spectra increase with decreasing concentrations of POPOP.

Figure 1*B* shows scintillation spectra from toluene solutions of 4 g/lit of ϕ_3 with varying concentrations of POPOP—namely, 0.1 g/lit, 0.003 g/lit, and no added secondary solute. These curves are comparable in this instance, being obtained under identical conditions, and the relative areas indicate the relative light-producing efficiencies of the solutions.

Also indicated by the vertical lines at 3580, 4120, and 4330 A in the figure for each scintillation spectrum is the mean wavelength, which is defined as that wavelength which divides the spectrum into two portions, each having an equal number of photons. This property is more significant when one is considering the usefulness of a compound as a secondary solute than the wavelength of the principal emission band. Concentrations of POPOP which are intermediate to the examples given here provide scintillation spectra that are intermediate in appearance. The effect of POPOP is still evident at 0.0001 g/lit.

Qualitatively, top-surface excitation spectra look like scintillation spectra for single-solute systems and for secondary solutes at concentrations where energy transfer from primary to secondary is complete. Thus, the more readily obtained spectra are useful for comparisons of spectral distribution of the light emitted from various scintillators. The relative intensities of spectra obtained by these two methods, however, are not the same. Relatively weak fluorescence spectra are provided by some of the better scintillators, which give scintillation spectra that correspond to their relative pulse heights.

One reason, of course, for these discrepancies is absorption, not only of the shorter-wavelength emission (*5*) but also of the exciting radiation before it reaches the volume of solution seen by the slit, and thus the relative intensities of spectra from various solutions will depend on the wavelength of exciting radiation, physical dimensions of the cell, and absorption properties of the solutions. The lack of correlation between fluorescence and scintillation spectra encountered under the afore-mentioned conditions certainly indicates that studies of scintillation processes by use of fluorescence techniques must be approached cautiously (*6*).

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References and Notes

1. F. X. Roser, *Science* 121, 806 (1955) and references cited therein.
2. Work performed under auspices of the U.S. Atomic Energy Commission.
3. F. N. Hayes *et al.*, *Nucleonics* 13, No. 12, 38 (1955); F. N. Hayes, D. G. Ott, V. N. Kerr, *ibid.* 14, No. 1, 42 (1956).
4. F. N. Hayes, B. S. Rogers, D. G. Ott, *J. Am. Chem. Soc.* 77, 1850 (1955).
5. R. K. Swank, *Ann. Rev. Nuclear Sci.* 4, 119 (1954).
6. A paper concerned with additional studies and examples is in preparation.

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Microbiological Assay of Vitamin B_{12} in Marine Solids

We wish to report some experiments on methods for determining vitamin B_{12} in marine muds and in solids suspended in sea water using the *Escherichia coli* mutant 113-3 (*1*). The basal medium employed is the same as that used earlier (*2*) but without the addition of thioglycollate. Different investigators recently have used various reducing compounds (*3*) or cyanide (*4*) in the growth medium or in preparation of samples for microbiological assay.

It can readily be shown that the vitamin-B_{12} activity of marine materials is increased by boiling the materials for a few minutes in aqueous phosphate-citrate